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Tagging and Playback Studies to Toothed Whales

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LONG-TERM GOALS

While atypical mass strandings of beaked whales have been linked to naval exercises using mid-frequency sonar, the causal chain of events from sound exposure to stranding has not been elucidated. We now know that beaked whales react strongly to sonar, killer whale calls, and bandlimited noise by ceasing echolocation and completing an unusually slow, directional ascent, in many cases leaving the area entirely (Pirotta et al., 2012; Tyack et al., 2011). Less is known about potential risks to other species of odontocetes overlapping with navy exercises. This project is part of a collaborative research program with the goals to:

a) Increase our understanding of the baseline ecology and natural variation in behavior for a deep-diving delphinid species, the long-finned pilot whale, *Globicephala melas*.

b) Compare responses of beaked whales vs other odontocetes to playbacks of mid-frequency sonar sounds vs other anthropogenic and natural signals.

c) Conduct combined visual and acoustic surveys for beaked whales and other cetaceans along with collecting oceanographic data for input into models to predict beaked whale distributions based upon characteristics of their habitats.

The ultimate goals are to predict the distribution of species at risk from sonar, to define dose: response curves for risk to beaked and other whales for exposure to naval sonars, and to suggest improvements for monitoring and mitigation.

OBJECTIVES

The objectives of this study, which involved tagging and playbacks to pilot whales in the Alboran Sea, were to:

- Increase the sample size of baseline data on pilot whales
- Conduct playback experiments to tagged pilot whales
- Increase the number of simultaneously tagged pilot whales to study social communication
- Refine methods to visually locate several animals simultaneously

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All of these objectives were met. The objectives for this fiscal year have involved further refinement of methods to analyze Dtag data to identify which animal is vocalizing, to study vocal behavior in different behavioral contexts, to further refine our methods to visually locate animals, and to link these locations and other visual observations to the Dtag data.

APPROACH

This study included a 6-week research cruise in 2009 on the NATO RV Alliance in the western Mediterranean Sea and two research cruises in 2010 (Med10) and 2011 (Med11) using smaller vessels to study pilot whales in the Alboran Sea using digital acoustic recording tags (DTAGs). We had already conducted survey and tagging research (including tagging a *Ziphius*) in 2008 at this site, in collaboration with the NATO Undersea Research Centre, using their research vessel Alliance and staff. We collaborated in the fieldwork with Ana Cañadas and other biologists from the Alnilam Marine Research Center from Madrid, Spain.

WORK COMPLETED

All three planned research cruises were successfully completed, providing a total of 34 tags placed on long-finned pilot whales. During these expeditions, our team has worked out field methods for more successfully tagging multiple animals and achieving relatively long tag attachment durations. In several cases, we achieved multiple simultaneous tag-ons within the same social group, allowing us to establish a more complete picture of pilot whale baseline behavior and vocalization rates in different social contexts. In preparation for continued fieldwork in 2012 in a new study area, the Strait of Gibraltar, our team continued development of a stereo camera system designed to measure the position, orientation and speed of whales within the field of view, and to quantify the spatial cohesion of a social group. This system will be important for measuring quantitative social behavior response variables in relation to controlled exposures of anthropogenic and natural signals, such as naval mid-frequency sonar. The most recent version was then field-tested during the recently completed summer 2012 research expedition to the Strait of Gibraltar. In addition, our team also continued development of software for processing the complex and extensive streams of multi-modal data that are collected during experiments with multiple simultaneously tagged animals. We now can compare acoustic cues such as intensity and angle-of-arrival to the two hydrophones in each tag to identify the source of individual signals. This multi-tag comparative approach allows us to identify the source of signals produced during foraging dives, and to identify the source of most, if not all, of the social communication signals produced at the surface where the animals may be moving closely together.

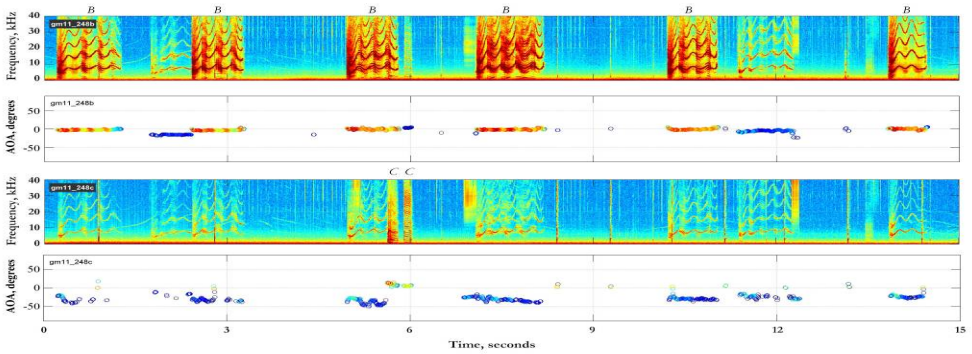

Fig. 1: Sounds recorded by DTAGs placed on two closely associated whales, gm11_248b and gm11_248c. The first and third row illustrates sound spectrograms showing the distribution of sound energy across frequency as a function of time, with dark red indicating very intense sounds, and blue indicating very faint sound. The second and fourth row shows the angle-of-arrival (AOA, in degrees) with respect to the two hydrophones contained in the DTAG. Using both sound intensity and angle-of-arrival cues, 6 calls have been identified as produced by animal B (labels above top spectrogram), and two shorter calls have been identified as produced by animal C (labels above bottom spectrogram). These sounds are characterized by higher intensity on the source animal, and a consistent angle-of-arrival equivalent to the angle-of-arrival of echolocation clicks during deep foraging dives. Note that the two unlabelled calls here were produced by two other simultaneously tagged whales (not shown).

RESULTS

The data collected during this project have allowed us to investigate the acoustic behavior and group coordination of social odontocetes with a level of detail not previously achieved. A key problem has been to correctly ascribe vocalizations to tagged and non-tagged animals. Carefully tagging closely associated individuals, where acoustic signals would be difficult to identify to individual, provides us with the information needed to make these classifications, and opens up the potential for a much more detailed look at social communication in cetaceans. The data collected under this project have made us realize how closely most of these pilot whale groups coordinate their diving behavior, and it has allowed us to identify different types of acoustic signals that are used for social communication during simultaneous and asynchronous individual foraging dives. Correctly identifying the source of calls allows for much more accurate estimates of individual vocalization rates for individuals in different life stages, including dependent juveniles, independent subadults, and adult animals (Figure 2) and compare to different behavioral contexts, including the vocalization rates observed during stranding, recorded during aggressive interactions with a sperm whale (SW) or during specific situations where animals need to relocate each other, such as after a non-simultaneous dive (Figure 2)

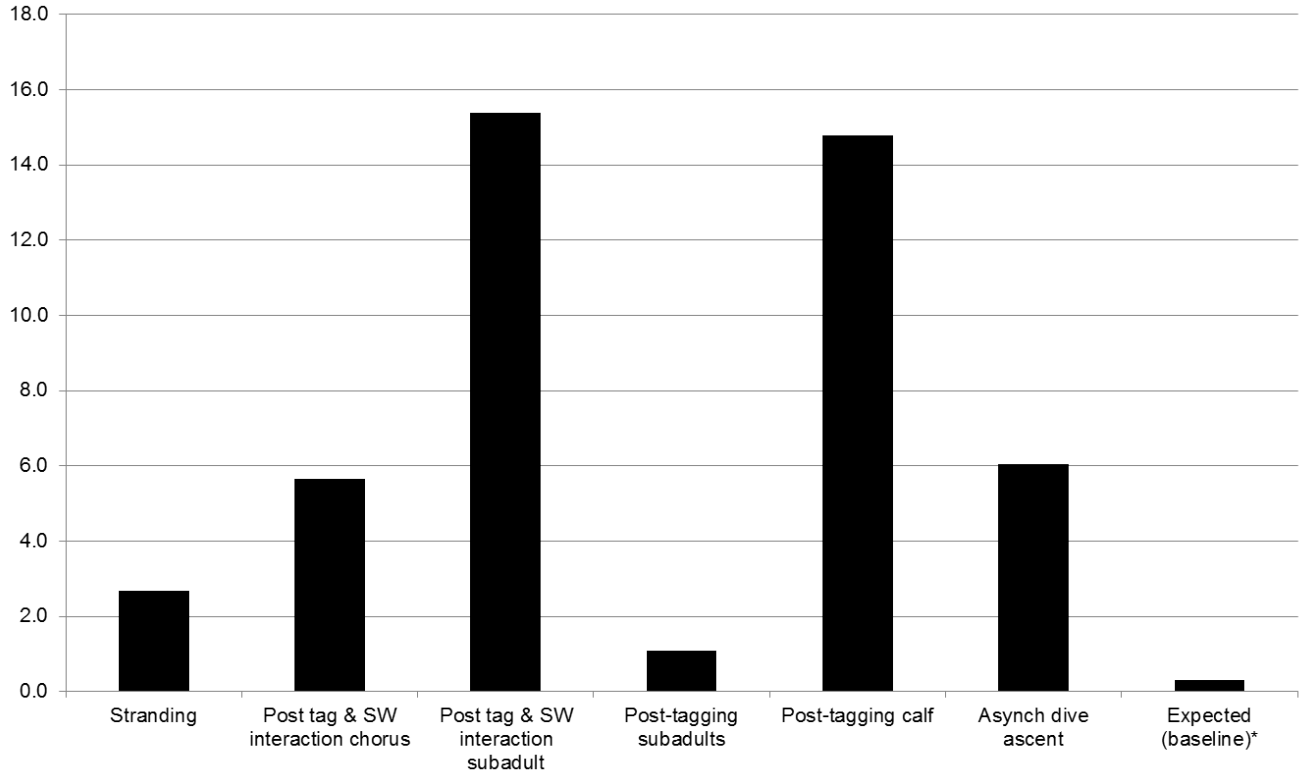

Fig. 2: Individual vocal rates (calls per minute) recorded from long-finned pilot whales in different contexts and for different age classes. These include stranded animals, aggressive interactions with a sperm whale (SW), repetitious call behaviour during the ascent from asynchronous dives, overall vocal rate of a subadult and a juvenile calf (likely 3-4 years old), and a baseline of average vocal rate from adult animals at the surface, excluding foraging and socializing. The first 30 minutes of tag time has been excluded to decrease the effects of tagging.

IMPACT/APPLICATIONS

The field methods developed here for tagging entire subgroups of long-finned pilot whales, in combination with the analytical tools for processing the large amounts of data in a multi-tag framework, provide a powerful tool for studying the social behavior and acoustic communication of odontocetes. The stereo camera system under development allows for accurate estimates of the GPS position, speed, and heading of animals within the field-of-view. This system has enormous potential as a method of quantifying changes in movement and social cohesion as part of a potential anti-predator response towards disturbances. In combination with simultaneous tagging of multiple whales, it also allows for simultaneous tracking of multiple whales and evaluating how different types of acoustic signals modulate the spatial configuration of groups of animals with different individual-specific social relationships. Earlier methods have focused on the problems that observers have in tracking more than one individual at a time, so they have focused on single focal individuals or have dropped individual observations in order to record behavioral states of groups (Mann 1999). Neither method is well suited to studying how communication mediates individual-specific relationships.

More playbacks of sonar have been conducted to pilot whales (*Globicephala sp.*), which are large pelagic delphinids, than to any other genus of cetacean. Interpretation of the effect of sonar has been

hampered by our lack of understanding of baseline behavior and reasons for behavioral transitions and variability in behavior such as calling rate. Information from simultaneously tagged whales has demonstrated that social variables, such as the spatial separation of the group, and the foraging behavior of conspecifics, may have a large effect on the acoustic and movement behavior of these highly gregarious animals. These investigations have already helped us identify separate acoustic mechanisms that likely mediate social cohesion of the group across different spatial scales. In particular, results showing how pilot whales use repeated, stereotyped calls (Sayigh et al. 2012) to re-establish contact with their social group following separations may prove valuable for testing whether monitoring for stereotyped calls might provide a more sensitive acoustic measure than overall call rate for evaluating social responses to disturbance. In general, these results should help us to interpret variation in calling behavior observed during previous controlled exposure experiments transmitting sonar sounds to pilot whales. We have contributed data to the 3S and MOCHA projects and will continue to make our developing results available to BRS collaborators and the broader scientific community. We expect that this project will contribute significantly to the long term goal of the BRS research program to understand whether and how delphinids may use strategies for social defense against threats, and whether this provides a lower risk for stranding in response to threats for this taxon. Such results will provide a critical scientific basis for acoustic criteria of harassment and risk of stranding.

RELATED PROJECTS

The study "Understanding the patterns and causes of variability in distribution, habitat use, abundance, survival, and reproductive rates of three species of cetacean in the Alboran Sea, western Mediterranean," award number N000141110196 to Ana Canadas of Alnilam, uses some of the data from the research cruises funded under this project. The data obtained in this study on responses of pilot whales to playback of killer whale sounds were made available to Charlotte Cure of the 3S2 project "3S2 - Behavioral response studies of cetaceans to naval sonar signals in Norwegian waters", award number N000140810661, so that they could boost their sample size of playbacks of killer whale sounds to pilot whales, and to add playbacks that used sounds recorded from mammal-eating killer whales. We are also making all of the data from this project available to the MOCHA project – "Multi-study ocean acoustics human effects analysis," award number N000141210204, so that they can use the data for innovative statistical analyses, and can pool the data with those from other studies in integrative analyses.

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PUBLICATIONS

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